

Research Collaborations and Scientific productivity among the Research Universities in South Africa

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Abstract:

This study presents the share of 5 most productive South African institutions for the main stream scientific output covering the 10 year periods of 1995-2004. This paper discusses the distribution of publications by institutions, Index of specialization, collaboration and pattern of co-authorship. The result shows that South African authors collaborate more frequently with international authors with a percentage of (73.99%) than did so for national collaboration which amount to (26.01%). This was confirmed statistically at the confidence level of P-value <0.025. A further non-parametric chi-square statistical analysis illustrated that there are significant differences in the proportion of co-authorship among the 5 institutions (p-value<0.005).

1. Introduction

The last few decades have witnessed a restructuring in scientific research. Increasingly, it is becoming a collaborative endeavour (Subramanyam 1983). According to Qiu (1992), there is also a strong trend towards borrowing from, and interpenetration across disciplines. As a result of these trends, there is a rise in collaboration both within and interdisciplinary collaboration in research and an increasing interest in it among both researchers and science policy makers.

International scientific collaboration has been of increasing interest in recent years due to the higher quality of collaborative papers as shown by higher average impacts when compared to solely national publications (Van Raan, 1998) and the benefit gained by peripheral countries from international collaboration for integrating their national publications onto the international scientific network (Russell, 1995).

2. *Objectives*

The purpose of this paper is to explore the main scientific output that can picture the extend of scientific development in South Africa. Specific objectives of the paper includes:

- To identify the main South Africa productive institutions during the period of 1995-2004
- To identify the institutions that are actively involved in the production of the main disciplinary fields
- To investigate the growth and development of south African scientific publications, 1995-2004
- To evaluate the percentage of international collaborations among South African scientists

3. *Methodology*

The analysis presented in this paper has been accessed from Scientific articles published in journals processed the online, CD-ROM and Web versions of the Science Citation Index (SCI) published by the Institute of Scientific Information (ISI) All papers recorded in the annual volumes of the Science Citation Index (SCI) of the Institute for Scientific Information (ISI) for the period of 1995-2004.

The following five most productive South African institutions were studied, They were Universities of Pretoria (UP), Cape town (UCT), Natal (NATAL), Stellenbosch (STELL) and Witwatersrand (WITS). The 7 main disciplinary fields are; Clinical Medicine (CLIN), Plant & Animal Science (PLT&ANM), Biology & Biochemistry (BIO&BICH), Engineering (ENGN), Environment & Ecology (ENV&ECO), Chemistry (CHEM) and Physics (PHY).

The performance of 5 institutions are judged and compared on the basis of the following qualitative and quantitative indicators, (a) size of scientific activity measured by volume of production during the period of study (b) each institutional fields of specializations using specialization index (SI) formula (c) Publication activity (d) the collaboration of scientific activity measured by co-authorship. Once retrieved, records were analyzed using Microsoft Excel to identify production distribution through out the period of study, distribution of publications by fields and institutions, and distribution by type of documents. To be determined whether one institution is more or less specialized (i.e. active) in a specific field compared to other institutions, the specialization index (SI) formula has been used (Godin, Robitaille, & Côté, 2001) It was calculated as share (%) of publications of institution X in field Y divided by the share (%) of publications of all institutions in field Y.

The study was also analytical in nature with the application of suitable statistical tools in strengthen the empirical validity. The computer software, SPSS was used to process it. Non-parametric Chi-square test was applied in the analysis of differences of co-authorship among institutions and t-test was used to justify differences in co-authorship rate. A further ANOVA analysis was conducted to reveal if significant inter-institutional variation in their total publication out put among mainstream exists.

4. *Findings and discussions*

4.1. *The Disciplinary distribution of South Africa publications*

Using the information available in the address field of the articles, the number of articles produced, from the most productive South Africa institution, has been calculated. In this study, articles from the 10-year period 1995-2004 have been included. We identified 19399 articles in total from 7 fields of study among 5 institutions. An analysis of the total out put presented in Table 1 indicated that

University of Cape Town (UCT) accounts for the largest share of South Africa publications 26.80% followed by UP (19.84%). The University of WITS and STELL have a publication share in the range of 18-19%. The University of Natal with 16.28% share accounts the least from all other institutions. A further statistical analysis has been employed to indicate if there was a significant level of inter-institutional differences identified on the total out put publications. However, the result of statistical analysis at p-value >0.10 does not reveal significant inter-institutional variation in their total publication out put.

Field (participation %)								
Institution	CLNIC	PLT&ANM	BIO&BIC H	ENGIN	ENV&EC O	CHEM	PHY	<i>1.1.1. Total*</i>
UP	560(14.55)	1436(37.31)	101(2.62)	441(11.46)	377(9.80)	332(8.63)	602(15.64)	3849(19.84)
UCT	1732(33.32)	873(16.79)	431(8.30)	671(12.91)	541(10.41)	411(7.91)	539(10.37)	5198(26.80)
NATAL	947(29.98)	714(22.60)	84(2.66)	319(10.10)	275(8.70)	324(10.26)	496(15.70)	3159(16.28)
STELL	970(26.51)	642(17.55)	161(4.40)	751(20.52)	321(8.77)	309(8.44)	505(13.80)	3659(18.86)
WITS	1516(42.90)	379(10.72)	158(4.50)	338(9.56)	232(6.56)	360(10.17)	551(15.60)	3534(18.22)
Total**	5725(29.51)	4044(20.85)	935(4.82)	2520(13.0)	1746(9.00)	1736(8.94)	2693(13.88)	19399(100)

Source: compiled by science citation index

*P-value >0.10

**P-value <0.005

Table 1. Distribution of publications according to subject field and institutions, 1995-2004

From disciplinary **Scientific** Publications throughout the period studied (1995-2004), the vast majority of South Africa publications came from the field of Clinical Medicine (29.51%). PLT&ANM science, PHY and ENGIN followed with 20.85%, 13.88% and 13.00% respectively of the departments' **output** for the period. The other disciplinary fields, in order of percentage contribution, were ENV&ECO (9.00%), CHEM (8.94%), and BIO&BICH (4.82%). All institutions made highest contribution in clinical medicine except UP (14.55%) in comparison to other fields of study. However, notable differences were found with respect to the contribution made by individual institutions to the different fields of study. University of Pretoria, for example, contributed heavily to PLT&ANM science (37.31%) and PHY (15.64%) and, the least in BIO&BICH with only 2.62% out of the total production. University of WITS on the other hand, has got the highest publication share in clinical medicine (42.90%) and lowest in BIO&BICH 4.50%). University of Cape Town and Natal were strong in the fields of Clinical medicine and PLT&ANM science while University of Stellenbosch showed its highest production in the fields of Clinical medicine(26.51%) and Engineering (20.52%).

In general, the coverage varies between different fields. Highest coverage is obtained for Clinical medicine and, plant and animal science. In Engineering and Physics the coverage is somewhat lower. In the CHEM and ENV&ECO the coverage tends to be poorer. The least contribution was from BIO&BICH. This disciplinary differences has been proved using the appropriate statistical analysis and it was found that **scientific** publication differences among 7 fields of study were justified at the confidence level of $p < 0.005$.

4.2. *South African most productive institutional activity*

The graphing of article counts annually is a bibliometric technique that determines how many articles have been devoted to a given concept over time. The rationale for this method is that bibliographic records are a relatively objective indicator for measuring discourse popularity (Ponzi& Michael 2003). Once information is published in the form of articles, annual counts can be captured to provide time-series data that can be charted and analysed. Based on the work of Abrahamson (1991, 1996) and Abrahamson & Fairchild (1999), the bibliometric technique of article counting is a reliable analytical approach to begin an analysis of the published literature in order to illuminate and trace the development of a concept.

The percentage increases or decreases are calculated taking 1995 as base year. The over all trends since 1995-2003 for all institutions except WITS and UCT which showed drastic percentage decrease from 1995 to 1996, but gradual increase in total article production was apparent. Looking at the trend for each institution, however, reveals important differences. Article production of Universities of Natal, UP and STELL showed highest percentage increase in 2003 from 1995, 84.10%, 108.10% and 105.10% respectively. However, their percentage increase declined in 2004 to 5.60%, 9.83% and 76.19% respectively. The annual volume of **scientific** publications of UCT highly declined in 1996 by 57.0% from 1995 and increased in 1997 to 81.80% even though it declined in 1998 by 59.20% (Figure 1). After this date, however, the trend reversed. The number of publications was increasing at a steady rate until 2001 after which the rate of decrease continued until 2004 although not very sunstantial.

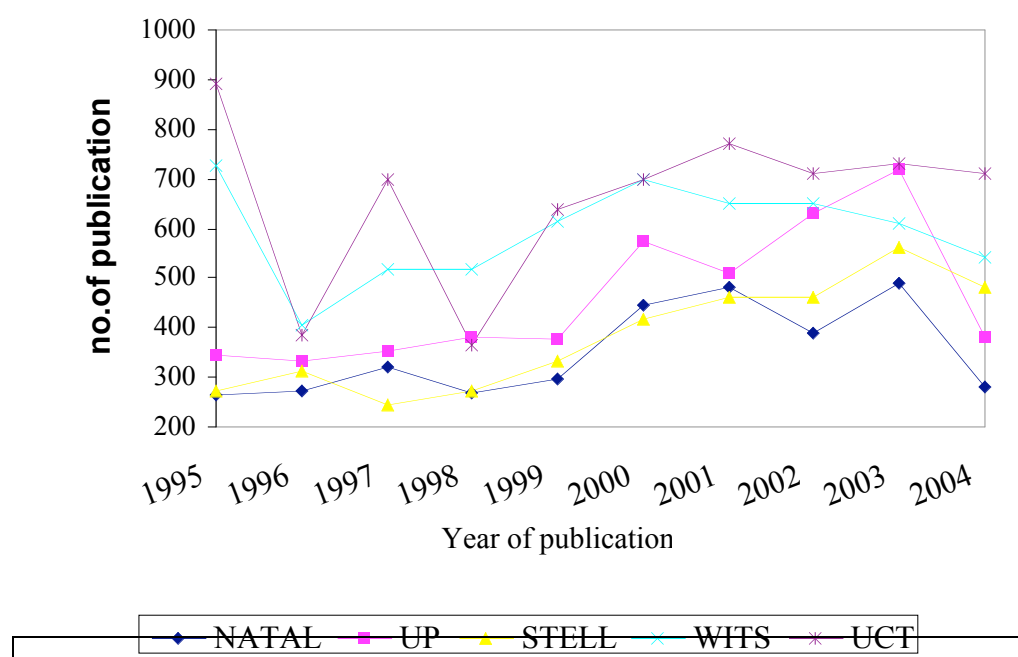


Figure 1. South Africa institutional publication activity (Data Source: SCI)

University of WITS showed a fairly steady increase in the number of scientific publications since 1996 to 2000, followed by relative stability up to 2002. A decline began in 2003(16.0%) but it was less rapid than that of 1996 (44.10%). In 2004, all institutional recorded output is lower than in 2003. The data available for 2004 are not necessary completed, so that it would be risky to state that the downward trend continued in that year as well. In general, the analysis of the institutional classification by year showed that there were two peaks in the distribution of the item general aspects, the first, and more marked between 1999 and 2000 and the second between 2002 and 2003.

4.3. Index of specialization

The absolute output of publication doesn't consider the size of the institution and discipline. The specialization index, therefore, makes it possible to determine whether an institution is more or less specialized in a specific field compared to other institutions. The specialization index of institution less than 1 means that the institution is not specialized in this field. In other words, it is less active in this field than the average of institution. If the index is higher than 1, this means that the institution is more active in a given field than the average of institutions in the same field (Godin, Robitaille, & Côté, 2001).

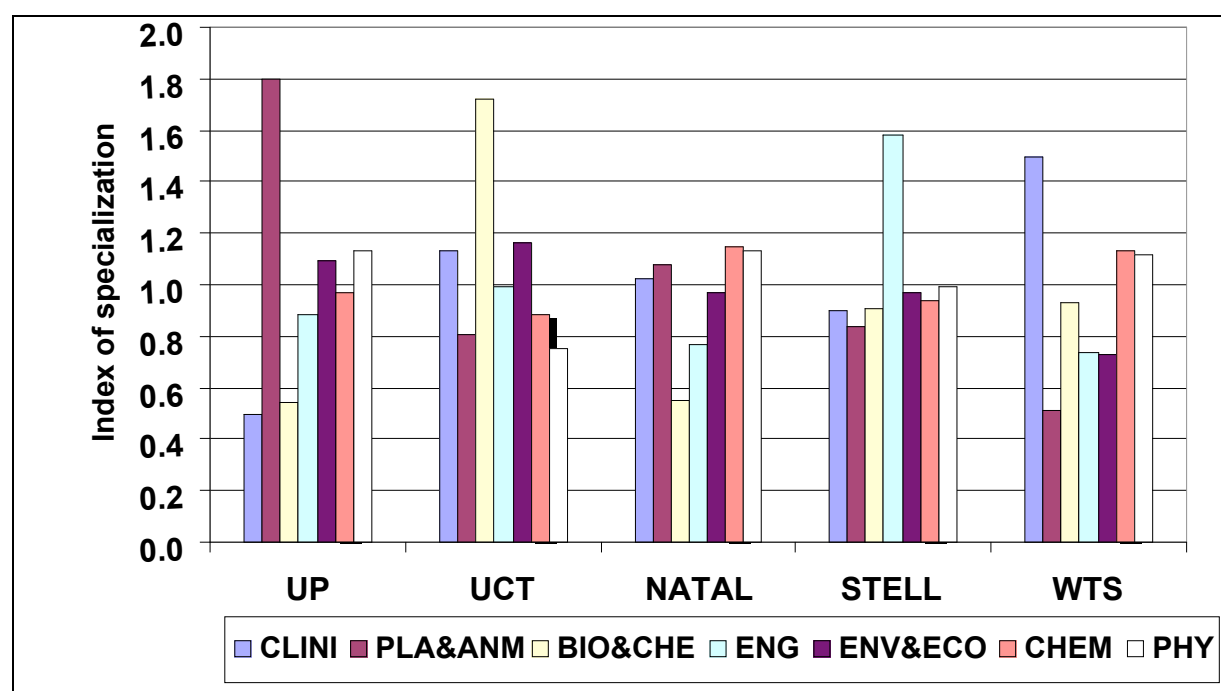


Figure 2. Index of Specialization (IS) for most productive institutions, 1995-2004

The specialization index, Figure 2, have been calculated for selected fields using publication data for the period 1995-2004. When interpreting the indicators one should consider that the specialization of the different fields varies considerably. Generally, UP has a high relative publication activity in the Plant & Animal science (SI=1.80) and Physics (SI=1.13). UCT, on the other way, specialized in Clinical Medicine (SI=1.13), Bio&biochem (SI=1.72) and ENV&ECO (SI=1.16). However, Universities of Natal and WTS have specialized in three disciplines; Clinical Medicine, Chemistry

and Physics. The analysis, moreover, shows that the field of Engineering has only specialized in STELL (SI=1.58). Similarly, UCT is the only institution that has specialized in Bio & Biochem (1.72).

4.4. **Scientific** collaboration

The globalization of science has resulted, among other things, in a generalized increase in international scientific collaboration making necessary updated information on scientific co-operation, co-authorship, and influence. This is important not only for the scientifically advanced countries but, perhaps, even more so for the developing world whose contribution to scientific achievement and legacy does not receive the same level of attention and reflection (Berthelemot, Russell, Arvanitis, Waast & Gaillard, 2001). There has been a significant increase in the number of internationally co-authored papers in many countries and so do for South Africa.

Analyzing the data of collaborations, Figure 3, signifies that the share of national co-authorship is about 26.01%, which is smaller than international collaborations 73.99%. Given international collaboration, South African authors' affiliation with USA and UK ranked first and second with 45% and 13% respectively in the period of 1994-2003. Other countries in order of ranking were: France (8.05%), Germany (7.80%), Netherlands (7.60%), Australia (3.40%) and Belgium (3.20%). However, the affiliation with other countries were very minute; such as Sweden (2.90%), Japan (2.70%), Canada (2.50%) and with African countries as a whole (3.20%).

A further analysis of institutional collaboration patterns showed that all institutional researchers, except UP scientists, collaborate comprehensively with international authors. The share of international collaboration by percentage among institutions were; STELL (91.25%), UCT (83.33%), WITS (78.22%) and Natal (68.84%) while the corresponding share in UP was 44.87%.

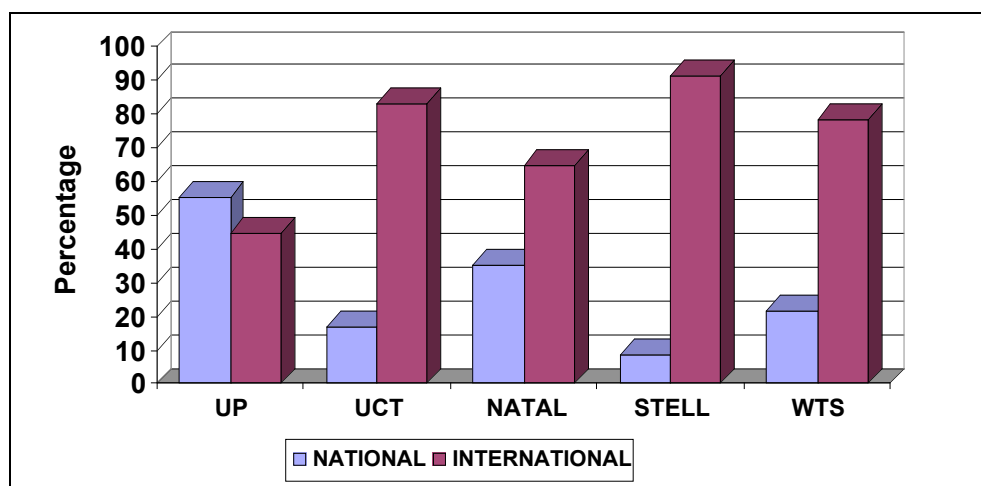


Figure 3 **Scientific** collaboration patterns in South Africa

A t-test was used to determine if there was a statistical significant difference between the means of national and international collaborations. The resulting p-value of 0.0185 (P-value < 0.025) indicates that South Africa authors collaborate more frequently with international scientists than did so for national.

The rate of international collaborations among institutions, Figure 3, point out that Universities of STELL (10.4), UCT (5.0) and WTS (3.5) ranked first, second and third respectively. This entails that authors from these institutions collaborate more internationally than of nationally. On the other hand, University of Pretoria achieved the lowest rate imply that the pattern of collaboration between national and international is somehow the same. A further non-parametric chi-square statistical analysis has been conducted to determine if there are significant differences in the proportion of co-authorship among the 5 institutions. The resulting, (p-value<0.005), shows that there are significant differences in the rate of collaborations among the institutions.

5. Conclusion

The result of our study showed that there were a total of 19399 articles from 7 fields of study among 5 institutions during 1995-2004 of which University of Cape Town (UCT) accounts for the largest share of South Africa publications 26.80% followed by UP (19.84%). The University of WITS and STELL have a publication share in the range of 18-19%. The University of Natal with 16.28% share accounts the least of all other institutions while growth of publications in each institution reveals important differences, gradual increase in total article production was apparent.

The majority South Africa Scientific Publications came from the field of Clinical Medicine (29.51%). PLT&ANM science, PHY and ENGIN followed with 20.85%, 13.88% and 13.00% respectively of the department's output for the period. The other disciplinary fields, in order of percentage contribution, were ENV&ECO (9.00%), CHEM (8.94%), and BIO&BICH (4.82%). Field of specialization varies greatly among institutions. UP, UCT and Natal have a higher relative publication activity in Plant & Animal science (SI=1.80), BIO&BICH (SI=1.72) and CHEM (SI=1.15) respectively. Whereas, STELL and WITS are more active in ENGIN (IS=1.58) and CLNIC (IS=1.50) respectively.

South Africa authors collaborate more frequently with international (73.99%) than did so with national (26.01%) even though the rate of institutional affiliation varies considerably. The international collaborations were highest with USA (45%) and UK (13%) and with other countries in order of ranking were: France (8.05%), Germany (7.80%), Netherlands (7.60%), Australia (3.40%) and Belgium (3.20%).

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